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AUTHOR Salisbury, David F.; And Others
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ABSTRACT

Suggestions for designing instructional practice activities, based on prominent instructional theories, are reviewed, and this is followed by a synthesis, in the form of a set of prescriptions for designing practice for various types of learning outcomes. The review of theories includes behaviorism and George Gropper's instructional model; Gagne and Briggs's classification of five types of learning tasks and nine events of instruction; Merrill's component display theory; cognitive research concerning automaticity, interference, spacing of practice and review sessions, and learning of meaningless material; and John M. Keller's work on motivation. The synthesis is represented by a matrix containing prescriptions for practicing nine different types of content: (1) facts; (2) paired associations; (3) names or labels; (4) connected discourse; (5) organized knowledge; (6) concrete concepts; (7) defined concepts; (8) rules and principles; and (9) procedures. For each type of learning material, suggestions are made about the following concerns: practice format; number of items involved; automaticity; motivational considerations; media requirements; learner strategies; and variations between early and final practice. (PN)

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Prescriptions for the Design of Practice Activities for Learning: An Integration from Instructional Design Theories

David F. Salisbury

Florida State University

Boyd F. Richards

Hazeltine Corporation

James D. Klein

Florida State University

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Abstract

Most instructional theories offer some unique and valuable suggestions related to the design of practice activities. However, the authors hold the view that no single theory or model is available which provides instructional designers with answers to many of the basic design questions related to practice activities. The purpose of this paper is to summarize the suggestions offered by various prominent instructional theories and then to combine the most useful suggestions into a coherent set of prescriptions. The first part of the paper contains our review and summary of the theories. In this review we attempt to draw out any suggestions and prescriptions given by each theory for designing practice. In the final part of the paper we present our synthesis in the form of a set of prescriptions for designing practice for various types of learning outcomes. We anticipate this set of prescriptions will prove to be a useful tool for designing the practice component of the instructional process.

Prescriptions for the Design of Practice Activities for Learning: An Integration from Instructional Design Theories

What should practice be like for different types of learning tasks? Various instructional theories include recommendations for practice activities for different types of learning tasks. Each theory offers some unique and valuable suggestions related to the design of practice activities. However, in our view, no single theory or model is available which provides the answers to many of the basic questions instructional designers frequently encounter in designing the practice component of instruction. For example, how much practice is required for skills which will later serve as subskills to more complex skills? Should separate skills be practiced separately or should they be mixed? Where and when should help and hints be used during practice? Should practice items be selected at random or in a predetermined sequence? In order to aid instructional designers in answering these questions, a more useful and complete model is needed.

The purpose of this paper is to summarize the somewhat piecemeal strategies and recommendations offered by various prominent instructional theories and then to combine the most useful ones into a coherent set of prescriptions. We anticipate this set of prescriptions will prove to be a useful tool for designing the practice component of the instructional process.

It might be appropriate to state why such a focus on the practice component of instruction is needed. One reason comes from research in modern cognitive learning theory which suggests that in order to perform complex intellectual tasks such as reading, computing, or computer programming many of the subskills involved have to be

automatized so that attention can be devoted to the more intricate and complicated aspects of the total task (Anderson, 1980; Resnick & Ford, 1981). The implication of this is that certain skills must not only be mastered but, through practice, must be brought to a state of automaticity.

Another reason to concentrate on practice stems from the increased use of computer-based training. Much effort is currently being made to utilize the computer to make practice more interesting and self motivating. However, there is still a need to better utilize this technology to optimize practice activities. Microcomputers allow designers to incorporate into practice strategies psychological techniques and procedures beyond what might otherwise be possible. However, designers will need some guidance in selecting the appropriate instructional techniques for various types of practice activities.

A third reason is the current use of authoring systems or templates for the design of CAI. Generally, the various authoring systems that have been developed offer only one strategy for practice while most instructional design theories prescribe different practice activities for different types of learning tasks. For this reason, several authors are recommending the development of more specialized templates for authoring. To quote Merrill (1981) "The use of templates would be more acceptable if a variety of templates were provided for the different types of learning." The integrative model proposed in this paper might serve as a foundation to the development of authoring templates for designing specialized types of practice activities.

The model set of prescriptions to be presented has utility as an aid to instructional designers, teachers, trainers, textbook writers, and developers of CAI. It also has value as a conceptual tool to

stimulate future research and questions heretofore unexplored or neglected.

Some theories have suggested that future advancements in the field of instructional design will be in two areas: 1. The synthesis of current knowledge about learning and cognition into more useful tools for instructional designers, and, 2. The creation of automated instructional design aids.

The first prediction is based on the observation that there is already a great deal of scientific knowledge about learning and cognition and what is needed now is a synthesis of those areas of knowledge which are most likely to increase the quality of instructional products. This is the purpose of the present paper. It is also hoped that this work will stimulate the formulation of other syntheses.

The second prediction suggests that in the future we will see the creation of automated instructional design aids. These aids could be described as expert authoring systems which would possess instructional design expertise as well as expertise about the content, programming, etc. Conceivably, automated instructional design aids will be created which will aid the designer in task analysis and selection of the most appropriate instructional strategies for various types of learning tasks. A first step in creating automated design aids will be the creation of models/strategies/prescriptions which could serve as the knowledge base for such systems. The set of prescriptions presented in this paper represents at least a prototype of a model which could become part of an automated instructional design aid.

Rationale for Selection of Theories

The authors deliberately selected theories which they felt would provide the most pertinent information for the design of practice. There are many good instructional models which we do not include because they concern themselves primarily with course development or large-scale curriculum or program development and do not provide recommendations for the design of the practice component of an individual lesson.

The motivational design model of Keller (1983) was included because the authors felt this to be an important aspect in the design of practice and one which is relatively neglected by the other instructional theories. While some of the theories regard motivation as an important element of instruction, none of them provide any concrete strategies for enhancing motivation.

In most cases the authors used original sources as resources for their review of the theories. We also used as a resource the descriptions of the theories given in Reigeluth (1983) due to the fact that this book contains the most recent and most accessible descriptions of these theories.

Behaviorism and the Design of Practice Activities

Behaviorism is concerned with those factors in learning that are external in nature. The behaviorist is interested in predicting and controlling behavior through stimulus/response reinforcement. In a behavioral approach, the learner is presented with a stimulus, and a response is made. The response is then reinforced. When a stimulus is presented repeatedly, and the appropriate response to it is made, the response is said to be under the control of that stimulus. Establishing

stimulus control depends upon two conditions: active practice of the correct response; and, reinforcement of the response following its practice.

Stimulus control is established through four levels of skill acquisition. These are: Discrimination level (learning to discriminate one stimulus from another), generalization level (learning to respond to any stimulus belonging to the same class of stimuli), association level (learning to associate an appropriate response with a stimulus or class of stimuli), and chaining level (learning to combine S-R associations into a complete chain). Learning to perform an activity involves learning to discriminate stimuli, generalize, associate and chain. The object of practice is to help the learner master all the S-R associations in an activity and the integration of them into a complete chain. Techniques such as incrementing, shaping, and fading are used to accomplish this.

One might view the behaviorist theory as a collection of general principles and concepts which govern the acquisition of a skill. George Gropper of Digital Equipment Corporation has done a great deal of work on integrating the general principles of behaviorism into concrete prescriptions for designing instruction (Gropper 1973, 1974, 1975, 1983). The remainder of this section generally follows Gropper's instructional model.

Gropper identifies six "tools" which instructional designers can apply directly to specific instructional tasks. In essence, these tools are components of the learning environment which can be varied to increase or decrease the demands put on students at any stage in a practice progression. Early practice sessions would be designed to

place less demand on students, intermediate practice sessions would increase demands on students in one or more ways, and final practice would require the student to perform the skill in criterion mode. The six tools are:

1. the degree of cueing that is provided for a practice task.
2. the size of the unit of behavior that is practiced in a practice task.
3. the mode of stimulus and response that is required in a practice task.
4. the variety that is built into a practice task.
5. the content that is built into a practice task.
6. the frequency with which a task is practiced.

The designer would use these tools to systematically vary the practice sessions so that early, intermediate, and final practice sessions would differ in one or more of these six ways. For example, in early practice, cues might be provided. In intermediate practice fewer cues would be provided, and final practice would not provide any cues. Gropper's model shows how to vary practice sessions using the six tools in order to increase the demand placed on students in the three stages of practice. Gropper provides prescriptions involving cue strength, behavior limit size, stimulus and response modes, practice example variety, content of practice and frequency of practice.

Gropper also provides suggestions for organizing practice treatments and matching practice treatments to objectives. The

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following table summarizes his recommendations for five types of learning objectives.

Table 1

Practice Treatments

Type of Learning	Initial Practice	Intermediate Practice	Final Practice
Learning Facts	o Tell students the facts they are to learn. o Provide cues to highlight the facts when a number of facts are to be learned at one time. (e.g., a table of basic multiplication facts highlighting pairs of numbers and their products.) o Require practice of only a few facts at a time.	o Have students apply the facts as well as state them. (e.g., using the basic multiplication facts.) o Fade cues used in initial practice. o Increase number of facts practiced.	o Have students apply all facts when possible. No longer require students to state the facts. o Eliminate all cues. o Have student practice the total criterion behavior (e.g., all multiplication facts are practiced in a random order.
Defining Concepts	o Define concept and ask student to state it. o Use cues to differentiate between instances and non-instances. o Have students classify instances. o Use concrete objects in early practice when possible.	o Continue to give instances and non-instances but make them more difficult to differentiate. o Have students generate some instances. o Still ask students to state definition. o Gradually make instances more abstract.	o Require students to state definition, and classify or generate instances <u>without</u> cues. o Make practice abstract, verbal, or symbolic.

Type of Learning	Initial Practice	Intermediate Practice	Final Practice
Giving Explanations	o Provide students with the explanation and require them to practice stating it. o Provide specialized cues (like flowcharts and demonstrations) to help students relate multiple concepts. o Give examples and non-examples of the explanation.	o Continue giving examples and non-examples but gradually make them more difficult. o Require students to produce their own explanations in their own words in addition to giving the model explanation. o Gradually fade cues.	o Have students state the explanation in their own terms without the use of cues. o Require students to use the concept being explained instead of just giving the explanation. (e.g., using the principle of reinforcement, not just stating it.)
Following Procedural Rules	o Provide students with the steps for following the procedure or give a demonstration of the procedure. o Require students to practice the steps in the procedure. o Break down long or difficult procedures into smaller units and practice the individual units (e.g., learning to drive may start with learning the rules of the road before getting behind the wheel.)	o Continue practice of the individual steps in the procedure. o Add additional steps to long or difficult procedural chains.	o Require students to practice the procedure in full with no breaks in the chain.

Type of Learning	Initial Practice	Intermediate Practice	Final Practice
Solving Problems	o Give students the rules needed to solve the problem. o Require students to recognize correct answers from incorrect ones. o Break up difficult or long problems into smaller units and practice the individual units (e.g., solving long division problems is practiced step by step).	o Give students a problem with a wrong answer and ask them to correct it. (Practice moves from the recognition phase to the editing phase) o Require learners to generate their own rules for solving a problem.	o Require learners to solve the problem with no help. (Practice moves into the production phase). o Ask learners to generate their own solutions when possible (e.g., answering long *division has a fixed* procedure, and unique solutions may not be found. Other problem solving can be unique.

Recommendations for the Design of Practice Derived From the Work of Gagne and Briggs

According to Gagne (1970, 1984), learning tasks can be classified into five categories: verbal information, intellectual skills, cognitive strategies, motor skills, and attitudes. The learning (and consequently the practice) within each category is different in important respects from the learning (and practice) in the other four categories.

Gagne and Briggs (1979; Aronson & Briggs, 1983) outline nine events of instruction which facilitate the different types of learning. Because different conditions are required for different learning outcomes, the nature of the events of instruction also differs for each

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type of learning outcome. The Gagne and Briggs theory also includes some guidelines for selecting instructional media. The nine events prescribed by Gagne and Briggs are shown in Table 2.

According to this formulation practice could be defined as the portion of instruction which takes place after the learner has initially been presented the material (events 1-5) but before the learner has mastered the material. This definition of practice views practice as what the learner does after having been guided through the material and before being tested (event 8). Conceivably, if the learner fails the test, he or she would need to go back for more practice (more of events 6 and 7). Enhancing retention and transfer is

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Table 2

Instructional Events

1. Gaining attention
2. Informing the learner of the objective
3. Stimulating recall of prerequisite learning
4. Presenting the stimulus material
5. Providing learning guidance
6. Eliciting the performance
7. Providing feedback about performance correctness
8. Assessing the performance
9. Enhancing retention and transfer

also accomplished in part through the practice component of instruction.

Practice drills which occur outside of an instructional presentation should probably engage the learner's attention, remind them of the objective, stimulate recall of prerequisite learning, and enhance retention and transfer of the skill being practice.

Some of the guidelines for selecting media coming from the theory are also applicable to the design of practice activities. Briggs defines instructional media as all methods used to present stimuli to students. In this sense, media includes not only audiovisual type materials, but also includes the teacher, role playing, observation, etc. Briggs recommends that media be selected separately for each instructional event depending on what conditions are necessary to present that event. Based on this idea, media for the practice component of instruction would not necessarily be the same as the media used to present the other events of instruction. Also, the selection of media for the practice of a skill will depend on the type of learning outcome involved.

Table 3 outlines the recommendations for events of instruction six and seven for the five different types of learning outcomes. The

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important thing to note is that the stimuli and the feedback differ for each type of learning outcome.

Component Display Theory and the Design of Practice

According to the Component Display Theory (CDT) (Merrill, Richards, Schmidt, & Wood, 1977; Merrill & Tennyson, 1977; Merrill, 1983),

Table 3

Practice Activities for Different Types of Learning

Learning Outcome/ SubCategory	Eliciting the Performance	Providing Feedback
Intellectual Skills		
Discriminations	Provide a variety of items which require learner to show that he sees two or more objects as different objects by responding to their names.	Indicate if response was correct or incorrect. For multiple discriminations also give correct response.
Concrete Concepts	Provide a variety of items which require the learner to point to two or more instances of the concept. The instances should differ as widely as possible in their nonrelevant characteristics.	Refer to properties present or not present in instances.
Defined Concepts	Provide a variety of items which require learner to identify the referents of the words which make up the definition and and show their relationship to one another.	Refer to the parts of the demonstration which were incorrect and tell why they were incorrect.
Rule Using	Provide a variety of items which require application of the rule.	Refer back to rule and show how correctly or incorrectly applied.
Problem Solving	Provide a variety of problems for solution	Change stimulus situation in response to learner's action and/or state the rule being followed or violated at each response.

Learning Outcome/ SubCategory	Eliciting the Performance	Providing Feedback
Verbal Information		
Facts	Ask learner to state each fact verbally.	Identify what is wrong or omitted from the statement of the fact.
Names/Labels	Ask learner to provide the name/label for each object.	Identify what is wrong or omitted in the name/label.
Connected Discourse	Ask learner to state the material verbatim.	Identify errors and state correct version.
Organized Knowledge	Ask learner to state proposition in own words.	Identify what is wrong or omitted from the statement of the proposition.

instruction to teach cognitive subject matter consists of a series of presentations that convey information or ask questions. These presentations, or instructional building blocks, can be described using five partially independent taxonomies. These taxonomies and their categories are as follows.

1. Type of content: Facts, concepts, procedures, and principles (rules).
2. Level of Performance: remember (recall, recognize), use (classify, demonstrates), and find (discover, deduce, derive).
3. Abstractness of Subject Matter: generalities (definitions, list of steps) and instances (examples, specific cases).
4. Presentation Mode: expository (tell, illustrate) and inquisitory (question).
5. Presentation Form: primary presentations (generalities, examples, and practice), secondary presentations (elaborations, helps, mnemonics, feedback), process displays (advice about how to learn), and procedural displays (instructions about how to use delivery media).

The CDT specifies the types of presentations (the mix of the 5 taxonomies) to include for effective instruction. In terms of the CDT, practice consists of inquisitory (4) primary presentation forms (5) that require students to demonstrate knowledge of generalities or instances (3) at any level of performance (2) and for any type of content (1).

The relationships among the 5 taxonomies can best be seen using three 2-way matrices. The first matrix (Figure 1) combines performance level and type of content. All practice activities of cognitive subject matter can be classified into one of the 10 cells of the

matrix. We have included a sample practice question in each cell as an illustration.

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Insert Figure 1 about here
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According to the CDT, learning is most likely to occur when instruction properly uses primary and secondary presentation forms. Primary presentation forms deal with the essence of the to-be-learned material. Secondary forms add to that essence such things as cues, background information, advice about learning, and feedback. Primary and secondary forms can be presented together (as an integrated display) or separately, depending upon the situation.

There are four types of primary presentation forms formed by crossing abstractness of subject matter with presentation mode. Figure

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2 contains this abstractness-mode matrix with a sample primary presentation in each cell. Practice consists of the right column.

There are eight types of secondary presentations. Use of each type depends upon the context, performance level, abstractness, and mode of the primary form to which it is associated. For example, one secondary presentation for an expository generality about a complex concept would be brief definitions of subconcepts. The most important secondary presentations for practice presentations are feedback and alternate representation of questions. The CDT prescribes the minimum set of primary and secondary presentations for each performance level

FIND		Sort these rocks into piles. Tell how somebody would sort them into the same piles later.	Write a computer program that will index and retrieve recipes.	Set up a demonstration that will help show how water gets into a well.
USE		Is this mountain a folded mountain?	Demonstrate how to clean a clarinet.	Explain why one of the two boats is much lower in the water than the other.
REMEMBER	What is the value of pi?	Define positive reinforcement.	What are the steps in balancing a checkbook?	Explain the three techniques used to make projection maps of the earth's surface.
	FACTS	CONCEPTS	PROCEDURES	PRINCIPLES

Figure 1. Performance-Content Matrix.

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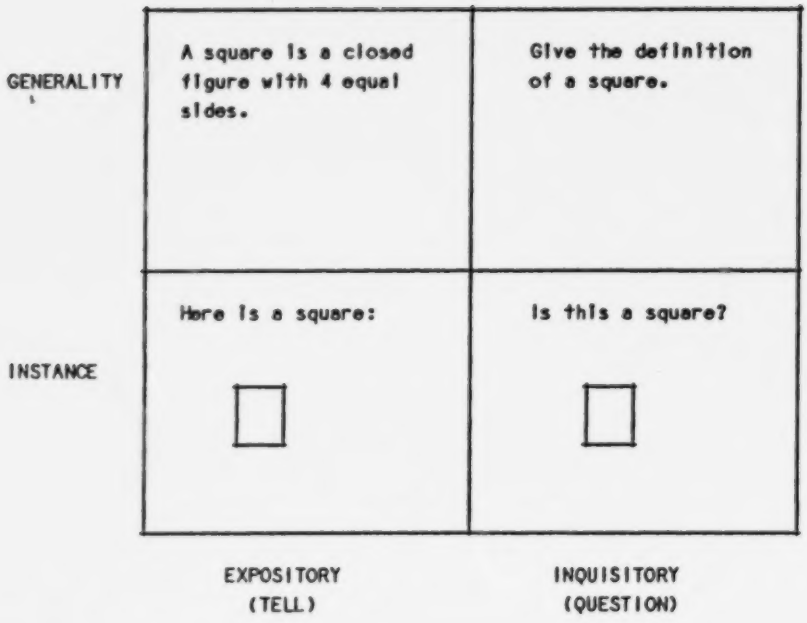

Figure 2. Abstraction-mode matrix.

and for each presentation mode. Figure 3 presents a brief summary of the prescriptions. Practice again consists of the right column.

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The CDT provides numerous guidelines regarding the quality and quantity of practice. We have summarized seven of them here:

1. Make practice activities (inquisitory presentations) consistent with the type of content and performance level specified in the objective.
2. Require a use or find level of performance as much as possible.
3. Embellish primary practice forms with secondary presentations, especially feedback. Match the feedback to the level of performances and type of content.
4. Systematically vary nonrelevant attributes of instances; make the set of instances as diverse as possible.
5. Gradually increase the difficulty of the practice.
6. Clearly separate and identify practice presentations from other primary and secondary presentations.
7. In many circumstances, give learners freedom to choose the number of practice presentation forms and when they see them in the overall instructional sequence.

Recommendations for the Design of Practice Derived from Cognitive Research

There are several issues arising from recent research in cognitive learning theory which are not incorporated per se in any of the

	EXPOSITORY MODE	INQUISITORY MODE
FIND		PPF*: 1) Give several problems that require finding solutions. SPF+: 1) Give new problems leading to new solutions. 2) For feedback, have students test each other's solutions.
USE	PPF: 1) State definition, list of steps or principle. 2) Illustrate generality with several examples. SPF: Give background info, review prerequisites and include attention focusing cues as necessary.	PPF: Give several problems. SPF: 1) Vary representation of problem and do not repeat them. 2) Provide feedback that includes why an answer is right or wrong.
REMEMBER: VERBATIM	PPF: Give facts, concept, procedure or principle or example of them depending upon which is to be memorized.	PPF: 1) Ask for exact recital. 2) Require recognition of an exact duplicate. SPF: Indicate with feedback if recall or recognition was correct.
REMEMBER: PARAPHRASE	PPF: Give fact, concept, procedure of principle and one example.	PPF: 1) Ask for a paraprased recital. 2) Require recognition of different representation of the same thing. SPF: Indicate with feedback if recall or recognition was correct.

* primary presentation form
\+ secondary presentation form

Figure 3: Minimum prescriptions for primary and secondary presentation forms classified in a performance-mode matrix.

instructional theories reviewed. In this section we present these issues and their implications for designing practice.

One important issue relevant to the design of practice activities which is not discussed per se in any of the instructional theories reviewed is the issue of automaticity. Automaticity refers to the state at which a skill ceases to consume much of the attentional capacity of the brain. This means that an automatized skill can be performed simultaneously with other tasks without interfering with the performance of those tasks. People commonly automatize skills such as typing, discriminating numbers from letters, or decoding common words.

Research suggests that the performance of complex skills such as reading, computer programming, or mathematical problem solving requires that many of the subprocesses become automaticized. (Lesgold, 1983; Resnick & Ford, 1981; Beck, Perfetti, & McKeown, 1982; Spelke, Hurst, & Neisser, 1976). It is not sufficient that these subprocesses be mastered, they must be brought to a state of automaticity or the performance of the higher-level task is impaired.

Practice drills intended to promote automaticity should include three stages. The first stage should concentrate on helping the student learn to perform the skill <u>accurately</u>. In the second stage speeded practice should be introduced until performance is both <u>fast</u> and <u>accurate</u>. The third stage should require the student to attend to a competing task or game while continuing to perform the original task until performance becomes <u>fast</u>, <u>accurate</u>, and <u>automatic</u>.

<u>Interference</u>

Most instructional theories emphasize how to teach a single fact, concept, rule, or procedure but do not give specific recommendations on

how to design practice for a set of them. Consequently, they have not thoroughly considered the issue of interference.

Interference occurs in practice activities involving many similar facts, concepts, rules, or procedures such as the learning of a set of math facts, preparing for a spelling bee, or memorizing foreign vocabulary words. Interference occurs when one stimulus-response association is confused with other stimulus-response associations. One type of interference, where new associations interfere with old ones, is referred to as retroactive interference. Another type of interference, where old associations interfere with the formation of new ones, is referred to as proactive interference. Both kinds of interference increase with the number of items to be practiced.

Designers can reduce the amount of interference present in a practice exercise by following a few simple guidelines:

1. Rather than having learners work on everything at once have them practice only a subset of the material at a time. By practicing on a small subset the amount of interference is reduced.
2. Since the strength of an association is weakened by the learning of new associations, review old items or material as new material is introduced. Once a subset of the material has been learned progressively introduce new material while systematically reviewing that already learned.
3. Compare and contrast similar stimuli with special cues so that the student can observe and note the differences. This is particularly useful to do when they are initially presented in a drill. As the drill progresses, diminish the cues completely. For example, suppose you wanted students to practice distinguishing among geometric shapes. Distinguishing a circle

from other common geometric shapes is more difficult if ellipses are also included in the drill. Since the potential for confusion between circles and ellipses is great you would contrast the differences between them early in the drill and continue to emphasize the differences until this specialized cue is not longer needed.

Spacing of Practice Sessions

There is much evidence in the literature to suggest that short, spaced periods of practice give better results than long concentrated practice periods (see Anderson, 1980). Studies on the effects of spacing have shown that the probability of recall of items increases proportional to the spacing between practice periods (Gay, 1973; Madigan, 1969). This spacing effect appears to be very robust and occurs with many different types of material. Bray (1948), for example, reported an experiment which showed that subjects could learn the Morse code with 4 hours a day of practice as rapidly as subjects who practiced 7 hours a day. The 7-hour a day subjects were apparently wasting the additional 3 hours of practice they were receiving per day. The reason spaced practice is considered to be more effective than massed practice is that the learning context on each occasion is somewhat different thus causing the information to be encoded somewhat differently each time.

Evidence about spaced practice suggests that practice activities should be designed so that learners can stop in the middle of a practice session or drill and then easily resume at a later time. The learner should be able to resume the drill picking up with the same items or material that he or she was working on during the previous session. In some cases, this can be done by dividing the content into difficulty

levels and allowing the learner to specify the appropriate difficulty level at the beginning of each new session. In other cases this requires that a record be kept of each individual learner which records the items that the learner was working on during the last session.

Spacing of Review Sessions

Spaced review has been shown to be a significant means of enhancing retention of learned material. For example, Tiedeman (1948) found that after two spaced reviews learners were able to retain for 63 days the same amount of information they would have retained for only one day without the reviews. Gay (1973) demonstrated the superiority of an early and late review over two early or two late reviews. Other studies have shown these same superior effects for spaced review over massed review (Ausubel & Youssef, 1965; Saxon, 1981).

The research on spaced review suggests that designers should provide for several reviews of mastered material and that each review should be spaced farther apart. This could be done by setting up a series of review stages allowing mastered material to be reviewed at different stages, say after a day, then after a week, then after a month. Drills might be designed to provide increasing-ratio review where the ratio of new items to review items changes as the student progresses through the drill. When the student first begins the drill all the items will be new items. As the student masters items, these become review items and are reintroduced systematically. Toward the end of the drill most of the items the student will be working with will be review items. Drills which are structured in this way might be used very effectively for the purpose of skill maintenance in addition to initial learning.

Making Meaningless Material More Meaningful

There is much evidence to indicate that people remember meaning and relationships rather than exact details. For example, Wanner (1968) had subjects listen to tape-recorded instructions and then, in a test, compare several alternative sets of instructions with the one they had heard. Results showed that subjects could identify changes in wording which resulted in changes of meaning but could not identify changes which were just stylistic. The same point has been demonstrated in experiments which have contrasted memory for meaningful sentences with that of memory for random word strings revealing that people remember the meaning rather than the exact wording of a verbal communication (e.g. Pompi & Lachman, 1967).

The superiority of memory for meaning over memory for details is accounted for by the idea of Propositional representation which is currently one of the most popular concepts of how meaning is represented in memory. This conception holds that the meaning of material is stored in the form of a proposition which includes only the meaningful parts of an event or learning task and does not include details considered to be unimportant (Anderson, 1976). People tend to exclude from their propositional representations material deemed unrelated or to which they cannot give meaning.

Because we can remember meaningful information better than meaningless information, instruction should seek to make material as meaningful as possible. Therefore, the objective of a good practice drill should not be just to "burn into memory" but to convert a learning task which does not have much inherent meaning into something more meaningful. This can be done through the use of mnemonic devices, keywords, and other memory techniques such as link, loci, or the

pegword method. The power of these techniques in improving memory of meaningless material has been consistently demonstrated (Atkinson & Raugh, 1975; Higbee, 1977; Bower, 1970a, 1970b, 1970c). Designers should incorporate them into practice activities which involve this type of material.

Another device that has been shown to be a very powerful way to give meaning to material is the use of mediators. A mediator is something which helps to associate a stimulus and a response that are not usually associated with each other. Ideally, the mediator should be something which the student already associates with both the stimulus and the response. Gilbert (1978) provides a good example of using mediators in practice. The task he wanted to teach was the color code for electrical resistors. On electrical resistors, colored bands are used to indicate the number of ohms of resistance. Each color stands for a number. For example, brown stands for the number 1, green stands for the number 5, and so on. The relationship between brown and the number 1 is arbitrary and meaningless. Therefore, Gilbert utilized mediators to help the student in learning these number-color associations. The mediator for brown and one was a penny since a penny is brown and also represents 1 cent. Gilbert reports that students using his list of mediators can master the code in one or two short practice sessions.

Table 4 summarizes the issues discussed above and summarizes relevant recommendations for the design of practice activities.

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Insert Table 4 about here
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Table 4

Recommendations for the Design of Practice Derived from Cognitive Research

Issues	Recommendations
Automaticity of subskills	In addition to accuracy, speed and the ability to perform the skill without interfering with a secondary task should be used as criteria for mastery.
Interference	Have the student drill on only a small subset of items at a time. Provide review of old items as new ones are introduced. Initially use cues to emphasize differences among competing stimuli and then fade the cues gradually.
Spaced Practice	Allow learner to specify the difficulty level at the beginning of each session or provide a mechanism to keep track of the items that a particular learner was working on during the last session.
Spaced Review	Gradually increase spacing between practice of mastered items. Utilize increasing ratio-review.
Making Meaningless Information Meaningful	Help the learning add meaning to the material by utilizing mnemonic devices or mediators.

Keller's Motivational-Design and Practice

It is widely accepted that motivation plays a role in how much a student learns. Even though this notion is believed to be true, some of our current theories fail to address motivation as a part of the design process. Others include motivation as one element in a particular model. Where does one look to find a complete theory of motivational design?

Researchers like John M. Keller of Florida State University have done a great deal of research in the area of designing motivating instruction. Keller's (1979, 1983) work in particular has produced many suggestions and recommendations on how to make instructional materials motivating to students. In this section of the paper we will summarize some of Keller's ideas as they relate to the design of practice activities.

Keller's model does not really represent an instructional theory per se. Rather, it draws together knowledge from various theoretical perspectives into a set of prescriptions for making instruction more motivating and engaging. Keller's model presents four basic categories of conditions which designers should consider in order to produce motivating instruction. These four categories are: attentions, relevance, confidence, and satisfaction. These four categories of conditions can be remembered by thinking of the acronym ARCS and Keller's model is sometimes referred to as the ARCS model (Keller & Dodge, 1982). Within each category, Keller offers strategies for making instruction more motivating.

Following is a skeletal summary of these strategies.

Attention

1. Vary the appearance and pace of instructional materials and activities.

- o Vary the medium of instruction
- o Vary the overall style of the presentation (fast-slow, active-passive, humorous-serious).
- o Vary the amount of student participation so that they can actively practice in challenging, yet safe situations (games, simulations, role playing).

2. Make abstract concepts and principles visible and concrete.

- o Use visual representations when introducing abstract ideas.
- o Provide examples of every important concept or principle.
- o Use content-related anecdotes and case studies.
- o Use props and concrete objects when possible.

3. Violate the learner's expectations by introducing conflict or uncertainty.

- o Present facts which contradict past experiences.
- o Present a paradoxical example of a concept.
- o Present conflicting principles or facts.
- o Present opinions that will surprise students.

Relevance

1. Relate the content to the student's past experiences.

- o Tell learners how the instruction builds on existing skills or knowledge.
- o Use analogies familiar to the student from past experience.
- o Relate materials to student interests.

2. Explain the present worth of the materials to the learner.

- o Explicitly state the present intrinsic value of learning the content and distinguish this from its value for future goals.

3. Describe the future worth of the instruction.

- o State explicitly how the instruction relates to future activities of the student.
- o Ask the learner to relate the instruction to their own future goals.

4. Include opportunities for personal need satisfaction.

- o Provide opportunities for students to achieve standards of excellence under conditions of moderate risk.

- o Establish trust, and provide an opportunity for no-risk, cooperative interaction.

5. Use positive modeling strategies.

- o Use those who finish first as student tutors.
- o Model enthusiasm for subject taught.

6. Provide opportunities for choice and self-determination.

- o Provide a meaningful alternative method for accomplishing a goal.
- o Provide personal choices for organizing one's work.

Confidence

1. Organize learning activities on an increasing level of difficulty.

- o Organize instruction in a clearly understood sequence.
- o Redesign activities which frequently cause failure.

2. Help students to overcome feelings of inadequacy toward content.

- o Build a bridge from context familiar to the student to a new subject.
- o Convince students of their ability to succeed.

3. Clearly state expected performance and evaluation standards.

- o State objective so that students can understand them.

4. Structure material presentation in identifiable units.

- o Provide practice of all skills related to goal performance after the entire goal is presented.
- o Begin a lesson with the more easily obtainable skills.

5. Allow students ample opportunity to identify and strengthen their own weaknesses.

- o Build remedial paths into a lesson design.
- o Allow a practice session before testing behavioral skills.
- o Call weaknesses in performance areas of improvement.

Satisfaction

1. Emphasize the natural consequences of learning a skill.

- o Allow a student to use a newly acquired skill in a realistic setting as soon as possible.

- o Verbally reinforce a student's intrinsic pride in accomplishing a difficult task.
- o Allow those who have mastered a task to help others.

2. Emphasize the positive outcomes of task mastery.

- o Give verbal praise for successful progress.
- o Provide informative feedback when it is immediately useful.
- o Provide motivating feedback immediately following task mastery.

3. Schedule reinforcements for learning in ways which will produce the most satisfaction within the learner.

- o Provide frequent reinforcement when a new task is being learned.
- o Provide intermittent reinforcement as a student becomes more competent at a task.
- o Vary the schedule of reinforcement on terms of both interval and quantity.

4. Give unexpected rewards.

- o Reward intrinsically interesting task performance with unexpected, noncontingent rewards.
- o Reward boring tasks with extrinsic, anticipated rewards.

Prescription Matrix

The objective of this paper is to synthesize suggestions for designing practice into a single organized set of prescriptions. In the first part of the paper we reviewed the theories from which we

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Insert Table 5 about here
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selected the recommendations. In the remainder of the paper we present our synthesis. This synthesis is represented by the matrix shown as Table 5.

As you will observe, the matrix has 9 rows. The rows contain prescriptions for practicing different types of content. We have defined each of the nine rows as follows:

1. Facts - learning of facts involves learning statements which are more or less isolated from other knowledge, such as the names of the months of the year, the terms of office of presidents of the United States, or the basic "math facts."

Table 5

Prescriptions for Designing Practice Activities for Learning

Type of Learning/ Considerations	Practice Format: Type of Stimulus	Practice Format: Stimulus Example	Practice Format: Type of Feedback Required	Number of Items: Single Item To Be Learned	Number of Items: Many Items To Be Learned	Automaticity	Motivational Considerations	Media Requirements	Learner Strategies	Variations Between Early and Final Practice
Verbal Information										
Remember Facts										
Remember Paired Associations										
Remember Names/ Labels										
Remember Connected Discourse										
Remember Organized Knowledge (Substance Learning)										
Intellectual Skills										
Use Concrete Concepts										
Use Defined Concepts										
Use Rules										
Use Procedures (Principles)										

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Table 3

Prescriptions for Designing Practice Activities for Learning

Type of Learning/ Considerations	Practice Format: Type of Stimulus	Practice Format: Stimulus Example	Practice Format: Type of Feedback Required	Number of Items To Be Learned: Single Item To Be Learned	Number of Items To Be Learned: Many Items To Be Learned	Automaticity
Verbal Information Remember Facts	Ask learner a question which requires him to state the fact.	o Who is quarterback for the Dallas Cowboys? (one fact) o Name the books of the Old Testament (many facts)	Identify what is wrong or omitted from the learner's statement and provide a correct model or answer.	Ask for recital of fact until mastered. After mastery, ask for fact after a day, a week, a month (increasingly spaced reviews).	Practice only 5 ± 2 facts at a time, once a fact has been learned, introduce a new fact and systematically review old facts interspersed with the new facts being learned.	Require recital of facts with speed, accuracy, and while engaged in a secondary task. A. Required if many facts are needed almost instantly while performing a procedure, rule, etc. (e.g., math facts while solving story problems). Also required if learner will need to use facts under pressure (e.g., in a press conference).
Remember Paired Associations	Give one of the pair and ask learner to supply the counterpart (if two-directional associations are required in real-world then each part of the pair must be presented as the stimulus.	o NA - learner supplies "Sodium" as response (one association). o Given a chemical symbol, provide the name of the chemical or vice versa (many associations).	Give praise for correct answer, give correct answer for wrong answer.	Present stimulus and get response (one or two directional depending on real world requirement. Review systematically while gradually increasing spacing between reviews.	1.One-way associations-same as facts 2.Two-way associations-once an association is learned in both directions introduce a new association. Old associations should be reintroduced systematically and should be reviewed in both directions.	Same as facts. A. required if the learner must ultimately make the associations as part of the performance of some higher level skill.
Remember Names/Labels	Give a picture of the object and have learner supply the label, or give label and have learner indicate the correct object.	Display an adjustable end wrench and ask learner to supply the name or display several tools and ask learner to identify the adjustable end wrench.	Give praise for wrong answer, for incorrect answer indicate what is wrong or omitted in the name/label.	See paired associations	See paired associations	See paired associations.
Remember Connected Discourse	Ask learner to restate material and indicate if restatement should be verbatim or paraphrase.	o State verbatim the Gettysburg address. o Give the definition of radioactivity (verbatim or paraphrase).	Identify for the learner any errors in the recitation and provide a correct model or answer.	Once learner can produce required restatement of material review systematically. (Break a long discourse into smaller segments and treat as many items.)	Have learner work on only 2-3 discourses at once. Once a discourse has been learned introduce a new discourse. Systematically review old discourses interspersed with new discourses being learned.	Require recital of material with speed, accuracy, and while engaged in a secondary task.
Remember Organized Knowledge (Substance Learning)	Ask the learner to reconstruct an organized representation of the material containing main and subordinate ideas arranged in a meaningful way.	o Recount the main ideas or themes from the Gettysburg address. o In your own words, give the definition of radioactivity.	Identify for the learner what is wrong or omitted from the paraphrase.	Once learner can provide a reconstruction of the material, review the original material systematically, each time learner should provide a more complete reconstruction to assure that learner is remembering the material and not just the reconstruction.	Have, worker work with 2-3 sets of material at a time. As a piece of material is learned begin working on a new set of material.	See connected discourse.

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Table 3 continued

Type of Learning/ Considerations	Practice Format: Type of Stimulus	Practice Format: Stimulus Example	Practice Format: Type of Feedback Required	Number of Items To Be Learned: Single Item To Be Learned	Number of Items To Be Learned: Many Items To Be Learned	Automaticity
Intellectual Skills						
Use Concrete Concepts	Ask learner to classify instances of the concept. All instances should be unique. Vary noncritical aspects of the instances so that the instances are as diverse as possible.	Which of these pictures shows a triangle?	For incorrect responses refer back to distinctive features of the concept and match definition to the instances.	Continue practice until learner can correctly identify instances and noninstances. Then review the concept from time to time gradually increasing spacing between reviews.	Once a concept is learned introduce a new concept. The learner will eventually be classifying stimuli as instances or noninstances of several concepts.	A. may be a requirement if concepts have to be identified as part of a higher level skill. In this case, practice should take the learner to the point at which learner can rapidly classify concepts while performing a secondary task.
Use Defined Concepts	Ask learner to generate instances of the concept by describing, drawing a picture or providing a definition.	o Watch the video tape and state whether the boy was treated fairly by his teacher. o Draw a "normal distribution."	Show how incorrect response differs from original definition of the concept in important ways.	Continue practice until learner can correctly demonstrate the concept. Then review the concept from time to time with increased spacing between reviews.	Have learner learn only 1 or 2 concepts at a time. Introduce new concepts while systematically asking learner to demonstrate those already learned.	Same as concrete concepts.
Use Rules (Principles)	Ask the learner to demonstrate the rule by applying it (in unique situations if possible).	o Generate the plural form of the noun nib. o Explain why Ice melts.	For incorrect responses refer back to rule and show how rule was violated.	Continue practice until learner can correctly apply the rule. Then review the rule from time to time gradually increasing spacing between reviews.	The simultaneous use of more than one rule is categorized as "problem solving." Provide examples for solution which require the learner to utilize several rules.	Similar to concepts.
Use Procedures	Ask the learner to execute the procedure.	Change the tire in five minutes or less.	Point out errors in execution of the procedure.	Continue practice until learner can correctly execute the procedure. Then review the procedure from time to time with increased spacing between reviews.	Once the procedure is learned introduce a new procedure. Review old procedures systematically.	

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Table 3 continued

Type of Learning/ Considerations	Motivational Considerations	Media Requirements	Learner Strategies	Variations Between Early and Final Practice
Verbal Information				
Remember Facts	o Begin with the more easily learned facts. o Reward boring tasks with extrinsic, anticipated rewards. o Tell learner how future instruction will build on this skill.	1. Quickly judge response and give feedback. 2. Reintroduce missed facts in new or random order. 3. Systematically reintroduce mastered facts for review. o Computers (best) o Flashcards (marginally acceptable)	Remind learners to use appropriate memory techniques (e.g., grouping, sequencing, or segmenting) to organize facts for easier recall.	Gradually increase number of facts being practiced. In early practice provide cues (tables, lists, etc.) to group meaningful relationships.
Remember Paired Associations	See facts	See facts	Increase meaningfulness of material by providing mediators or teach learners to provide their own.	Gradually increase the number of paired associations being practiced. In early practice provide cues gradually fading cues in later practice.
Remember Names/Labels	See facts	See facts	See paired associations.	See paired associations.
Remember Connected Discourse	o Vary the medium (verbal vs. written). o Reinforce a student's intrinsic pride in accomplishing a task.	1. Allow learner to give response with as little technical difficulty as possible. 2. Efficient response judging and feedback.	Provide visual images or teach learner to produce own visual images to help recall the material.	In early practice provide specialized cues like flowcharts, diagrams, to help students recite discourse.
Remember Organized Knowledge (Substance Learning)	See connected discourse	See connected discourse	See connected discourse	In early practice provide specialized cues like flowcharts, demonstrations, etc. to help students reconstruct an organized representation of the material.
Intellectual Skills				
Use Concrete Concepts	o Use metaphors to make complex relationships between concepts more complete. o Present a prodoxical example of a concept.			Gradually increase difficulty of examples. In early pratice provide cues to help learners distinguish instances and non-instances.
Use Defined Concepts	See concrete concepts.			See concrete concepts.
Use Rules	o Related current instruction to past experience. o Explicitly state the present intrinsic value of practicing the rule. o Allow student to use a newly acquired rule in a realistic setting.			In early practice provide students with job aid, list of steps, etc. to help students apply rule.
Use Procedures (Principles)	o Provide intermittent reinforcement when a student becomes more competent at a procedure. o Ask learner to relate the instruction to their own future goals.			In early practice provide students with job aid, list of steps, etc. to help students execute procedure. Practice subparts of the procedure separately in early practice.

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2. Paired Associations - learning paired associations involves learning to associate two things (stimulus and response) together such as foreign and English vocabulary words, a chemical symbol and its name, or a letter of the alphabet and its name.
3. Names/Labels - learning names or labels are similar to paired associations but usually require the student to associate the name or label with a real object (or picture of an object).
4. Connected Discourse - learning connected discourse involves meaningful poetry or prose that is to be recalled verbatim. It may involve the memorization of short definitions, statements, or questions which can be paraphrased.
5. Organized Knowledge - learning of organized knowledge involves the learning of various propositions, ideas, or concepts and the formation of those into an organized body of knowledge. This can also be referred to as "substance learning" since the learner is concerned with the substance (main idea and subordinate ideas, concepts, relationships) of the material being studied. Learning about a particular era of history or a particular branch of science are examples of learning organized knowledge.
6. Concrete Concepts - learning concrete concepts involves learning to identify the members of a class of objects (e.g., identifying Volkswagens, open end wrenches, altimeters, or disk drives).
7. Defined Concepts - learning defined concepts involves learning the meaning of a concept which exists only by definition (e.g., the concept of family, male, student, or perpendicular).
8. Rules (Principles) - learning rules or principles involves learning to apply a sequence of concepts and actions to a task.

Performing mathematical operations or writing statements in a computer programming language are examples of rule governed tasks.

9. Procedures - learning procedures involves learning to perform an action which involves a number of sequential steps. Learning to change the oil in a car, or to "boot up" a microcomputer are examples of procedures.

Note that we have included in the matrix only types of content which fall under the "verbal information" and "intellectual skills" categories of Gagne and Briggs or the "remember" and "use" categories of Merrill. We have not included recommendations for practice of cognitive strategies ("find" category of Merrill), motor skills, or attitudes.

The matrix has seven major columns. Each column contains prescriptions for a single area of concern. The following is a brief description of each area.

1. Practice Format - this area is concerned with what type of stimulus and feedback is required during practice of the skill.
2. Number of Items Involved - this area is concerned with considerations for designing practice of one item or piece of material as opposed to designing practice of many items or a lot of material. The first column under this area contains recommendations for the practice of only one "item" (e.g., one fact, one paired association, one discourse, one concept, one rule, one procedure). The second column under this area contains recommendations for the practice of many "items" (many facts, many rules, etc.).
3. Automaticity - this area gives recommendations for helping learners automatize subskills should this be required.

4. Motivational Considerations - this area is concerned with strategies which are particularly suited for making practice of each type of learning objective more motivating. Most of these strategies are taken from Keller. It should be noted that the motivational strategies suggested by Keller are not restricted to any one type of learning outcome. Most can be applied to any type of learning. The matrix is an attempt to expose the reader to a few of these strategies.
5. Media Requirements - this area is concerned with the required instructional qualities and capabilities of media to be employed for practice.
6. Learner Strategies - this area is concerned with strategies which the learner can use for more efficient learning of the material.
7. Variations Between Early and Final Practice - this area is concerned with important differences which should be present in early, middle, and final practice.

The matrix will ultimately include recommendations for each cell. At this point there are still some cells which are not filled in. Additional recommendations will be included and other modifications and refinements of the matrix are anticipated.

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